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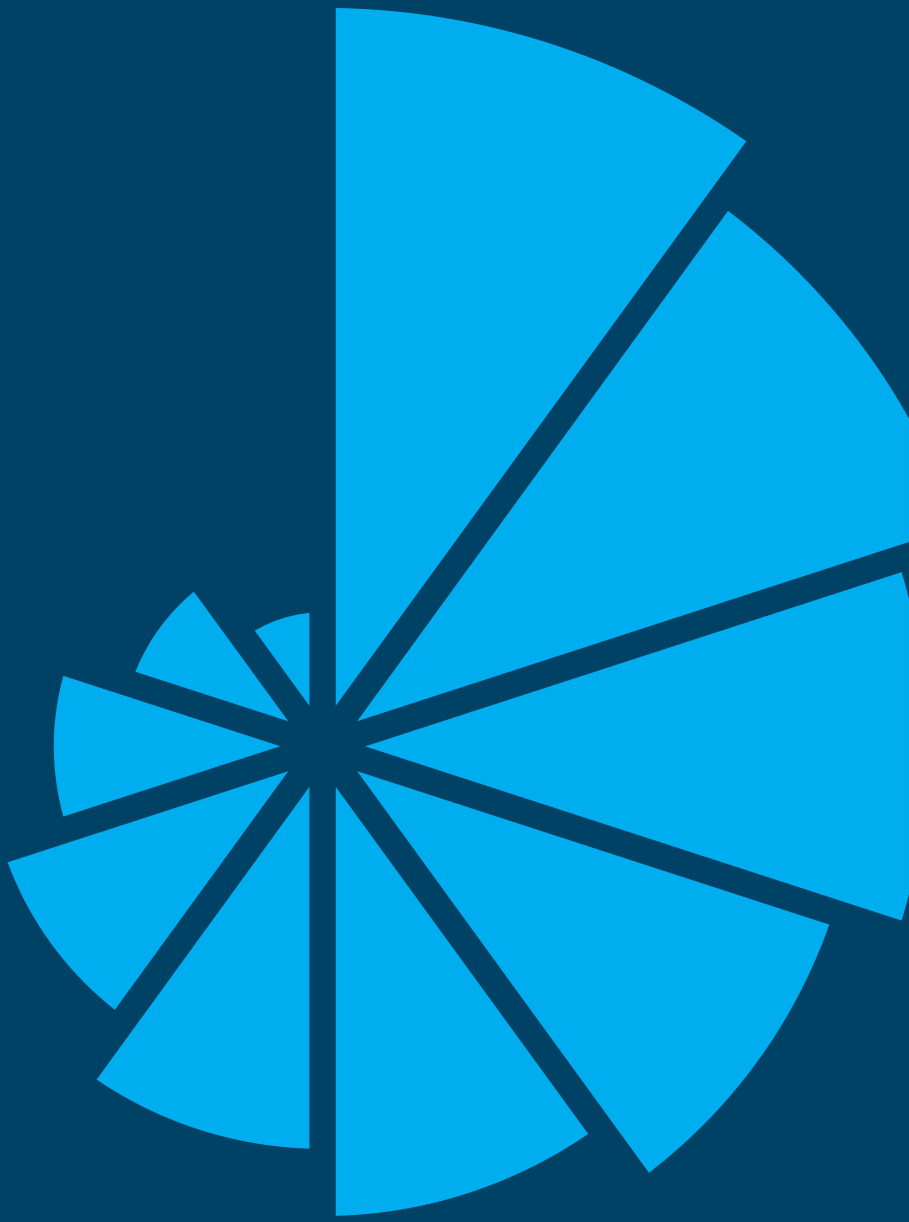
DEDICATED RELIABLE CREATIVE

Elenos Group Webinar:

FM Single Frequency Networks
Theory and Practice



Innovation lives here

Webinar Schedule

- Million Dollar Question
- SFN Basics
- SFNs for television
- SFNs for FM radio
- SFNs for HD Radio
- Your questions

Your host:
Chuck Kelly
VP Market Development

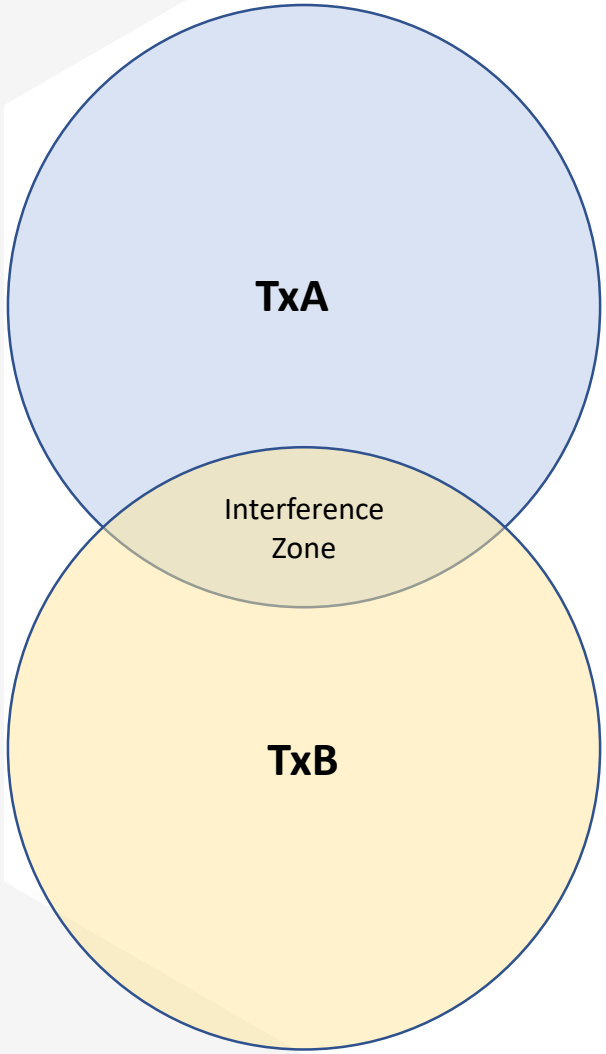
Special Guest:
Morten Simonsen
CTO – Elenos Group

Remember, watching this webinar qualifies for ½ credit towards SBE certification under Category 1.

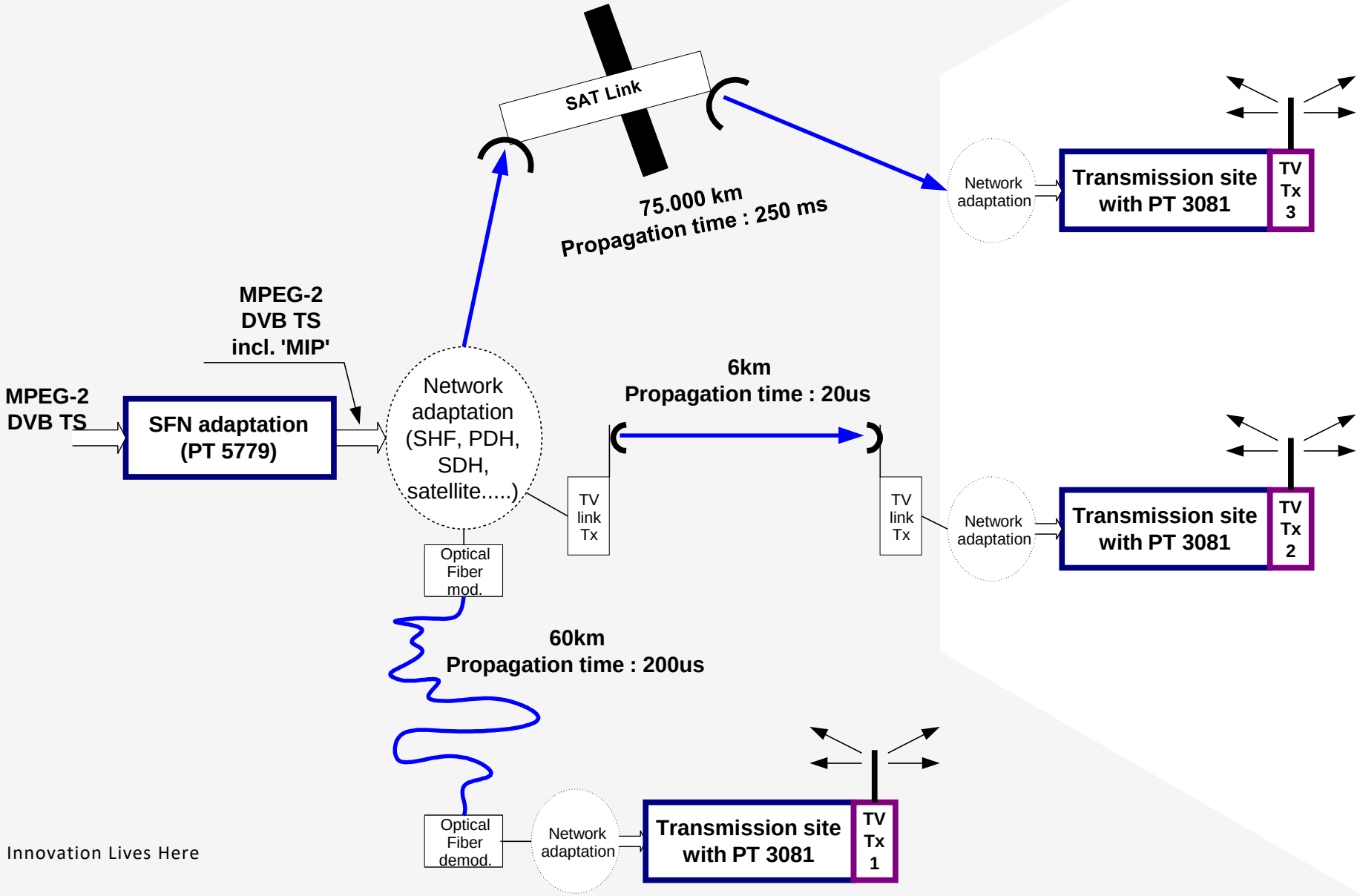
The Million Dollar Question

SFN Basics

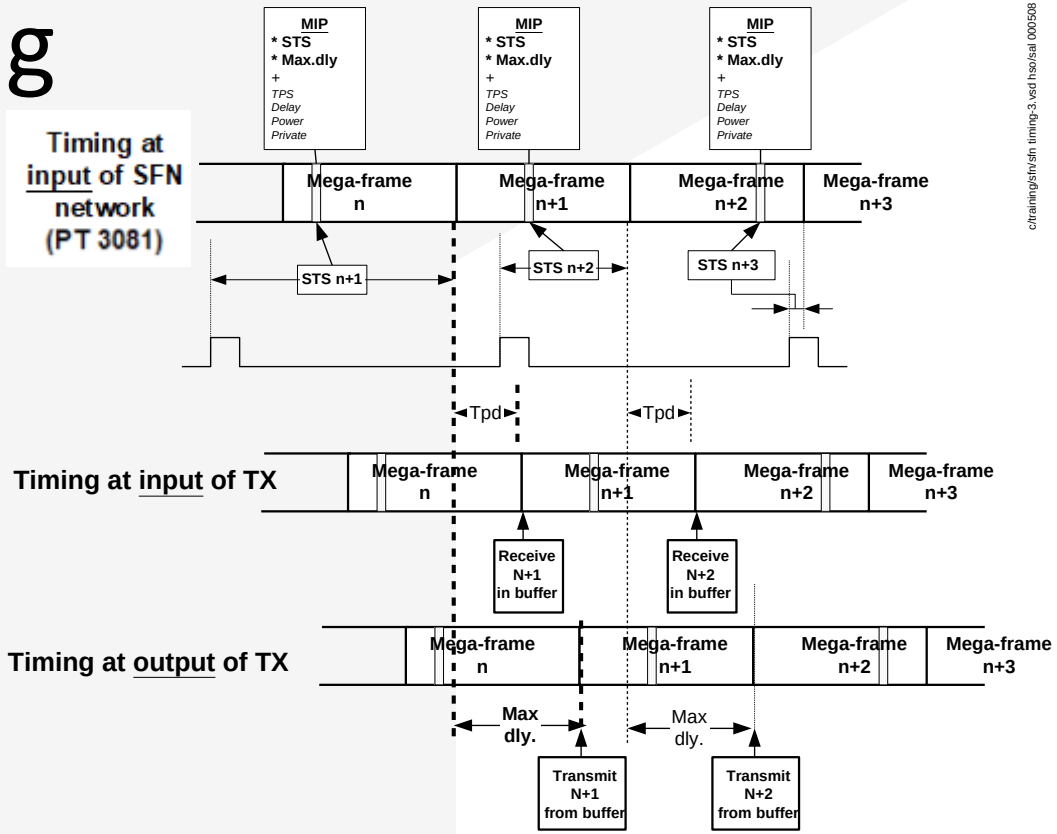
- SFN is “Single Frequency Network”
- It allows continuous coverage from one transmitter area to another, and makes more efficient use of spectrum.
- SFN requires careful coverage planning, and precise timing.
- For digital TV and DAB, a “guard interval is used, but this is not possible for analog.
- This means analog SFNs are actually more difficult than digital. D/U ratios of 4dB or worse constitute the Interference Zone.



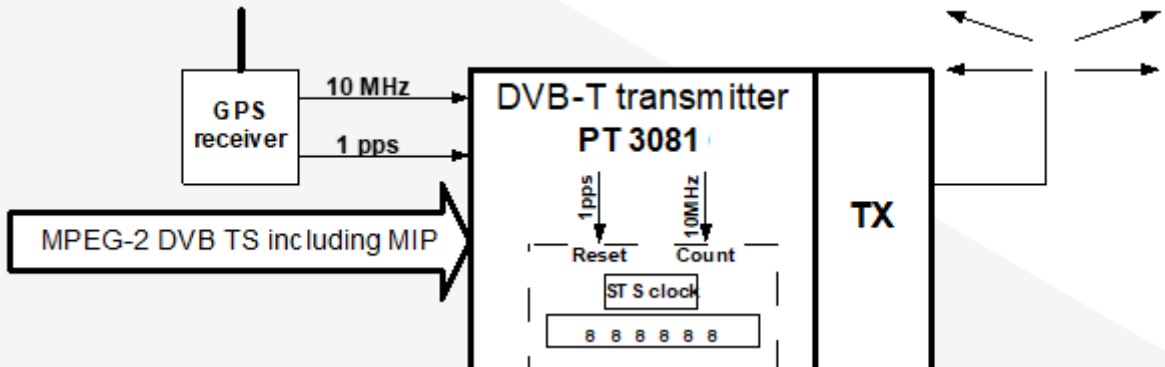
Digital Television SFN structure



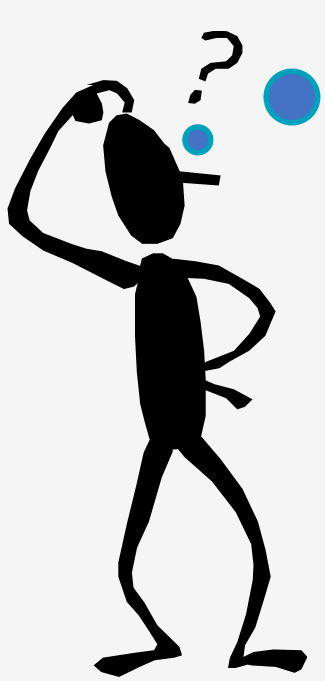
SFN Modulator Timing



Transmit time (STS clock) = STS + Max delay +/- Loc.dely +/- Opt.delay

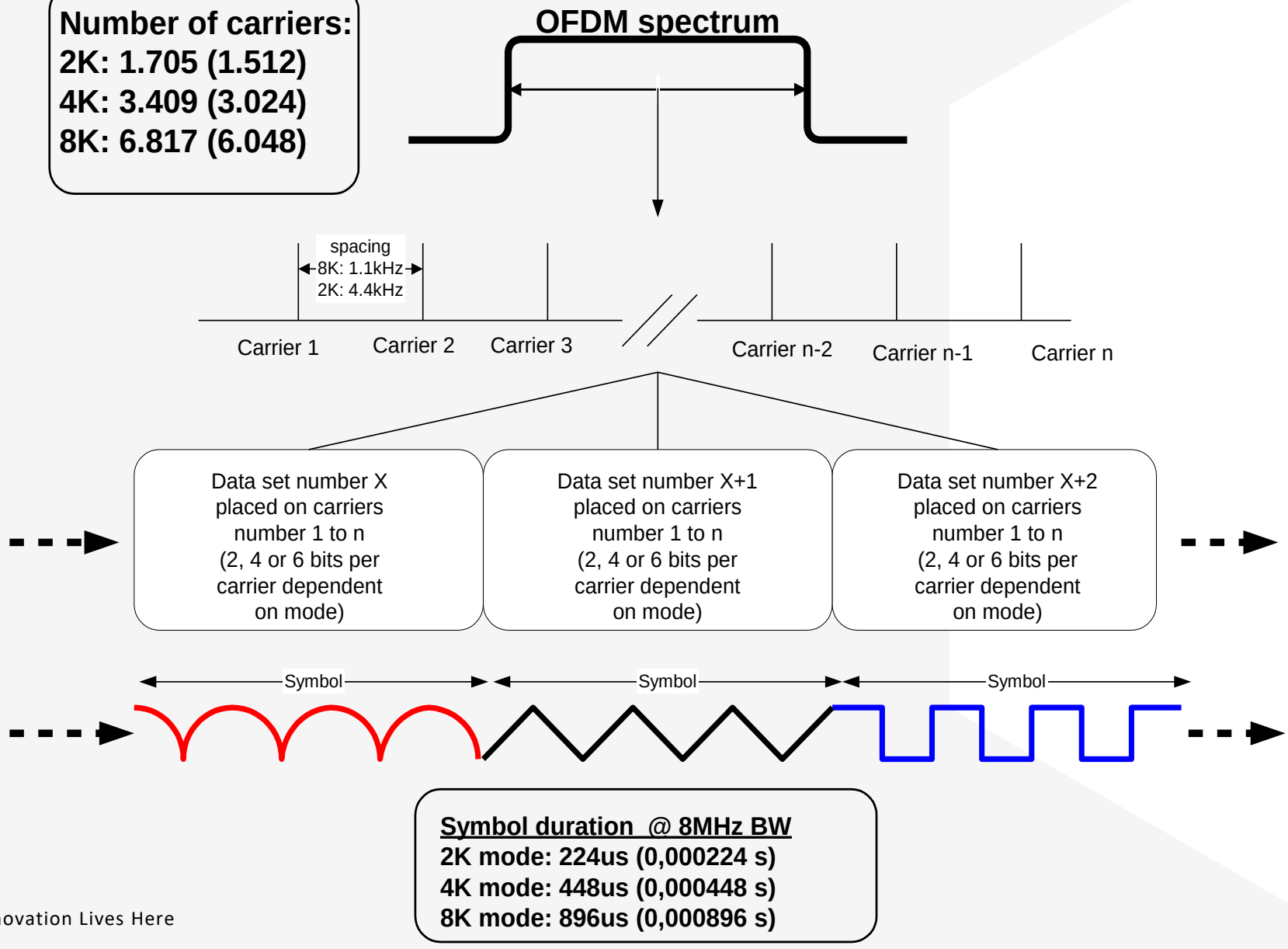


The Guard Interval, what is it used for and how is it created?



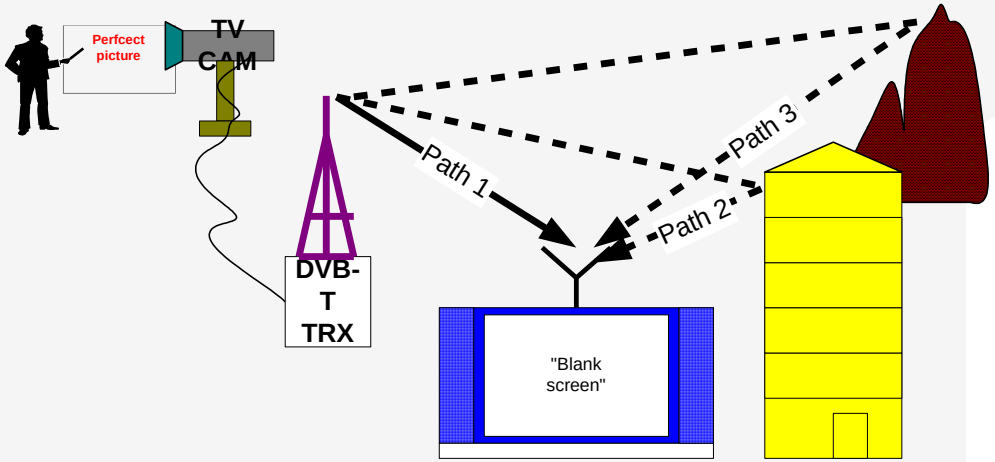
COFDM symbol without guard interval

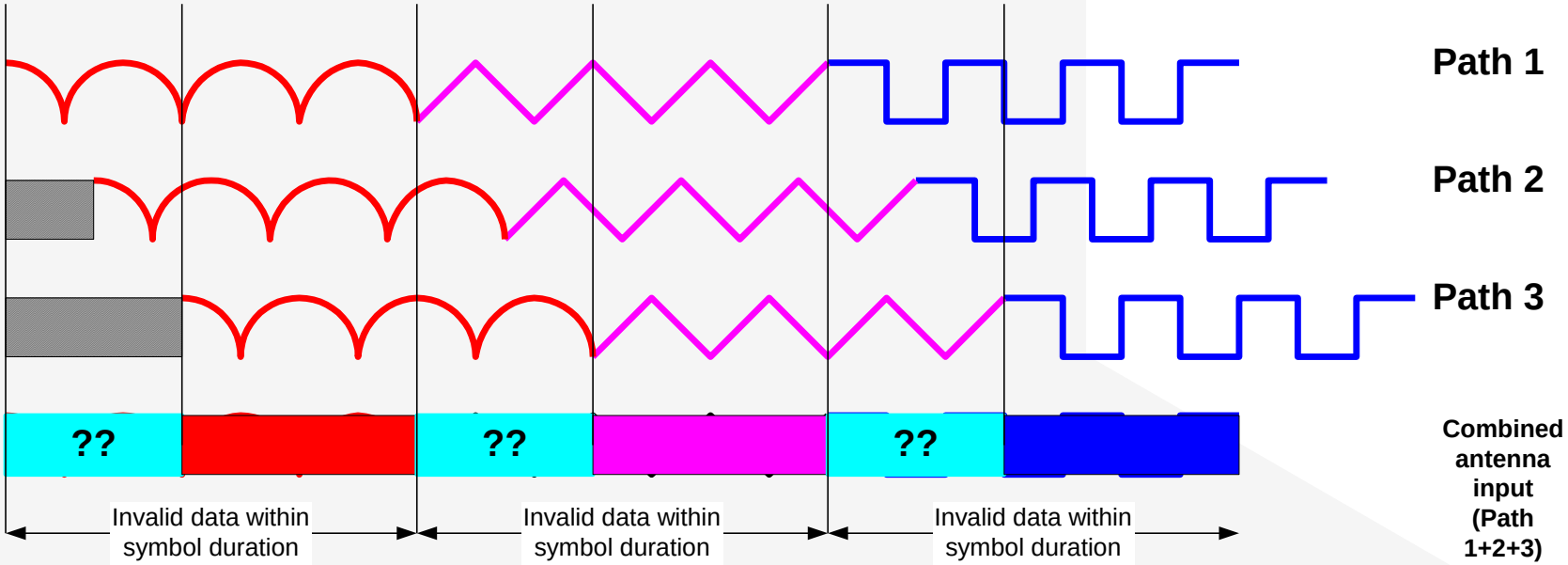
Number of carriers:
2K: 1.705 (1.512)
4K: 3.409 (3.024)
8K: 6.817 (6.048)



<u>Symbol duration @ 8MHz BW</u>
2K mode: 224us (0,000224 s)
4K mode: 448us (0,000448 s)
8K mode: 896us (0,000896 s)

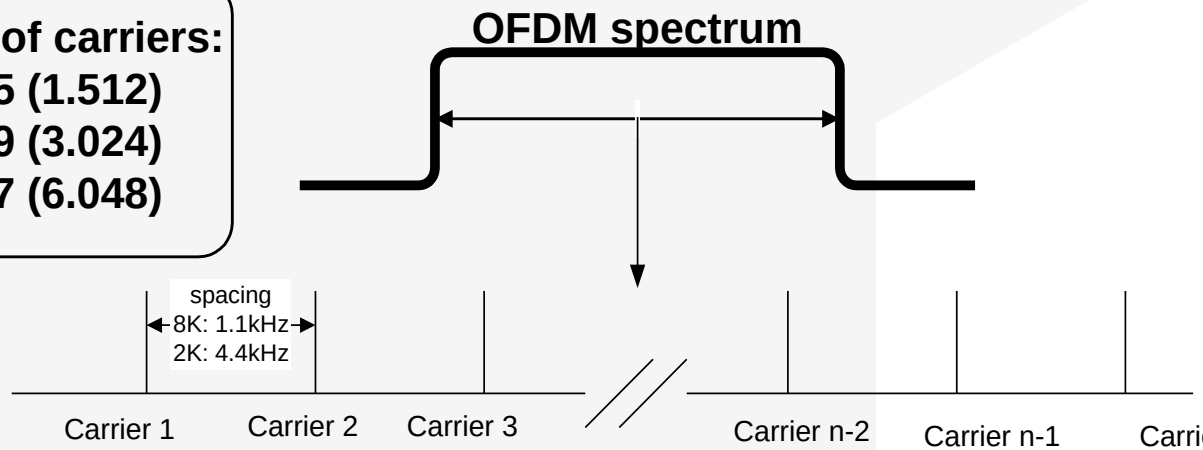
Reception of signal without guard interval





COFDM symbol with guard interval

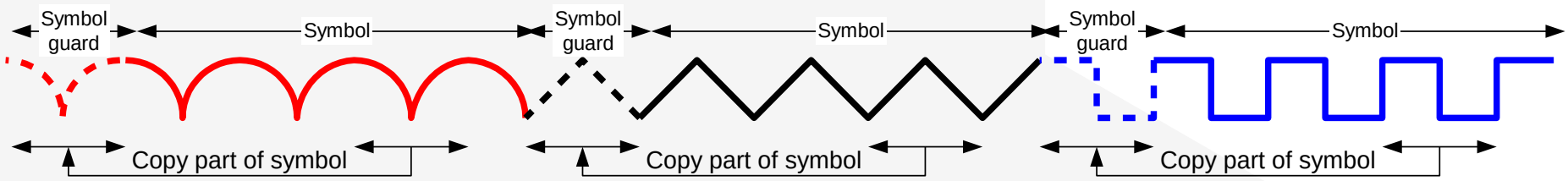
Number of carriers:
2K: 1.705 (1.512)
4K: 3.409 (3.024)
8K: 6.817 (6.048)



Data set number X placed on carriers number 1 to n (2, 4 or 6 bits per carrier dependent on mode)

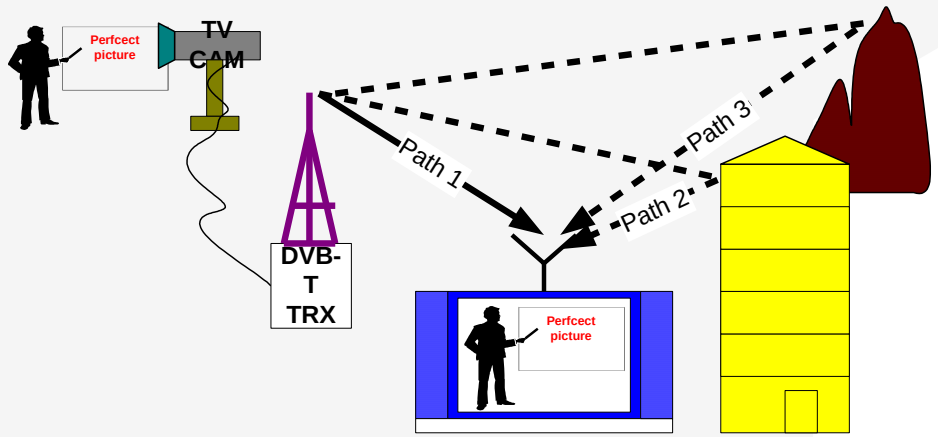
Data set number X+1 placed on carriers number 1 to n (2, 4 or 6 bits per carrier dependent on mode)

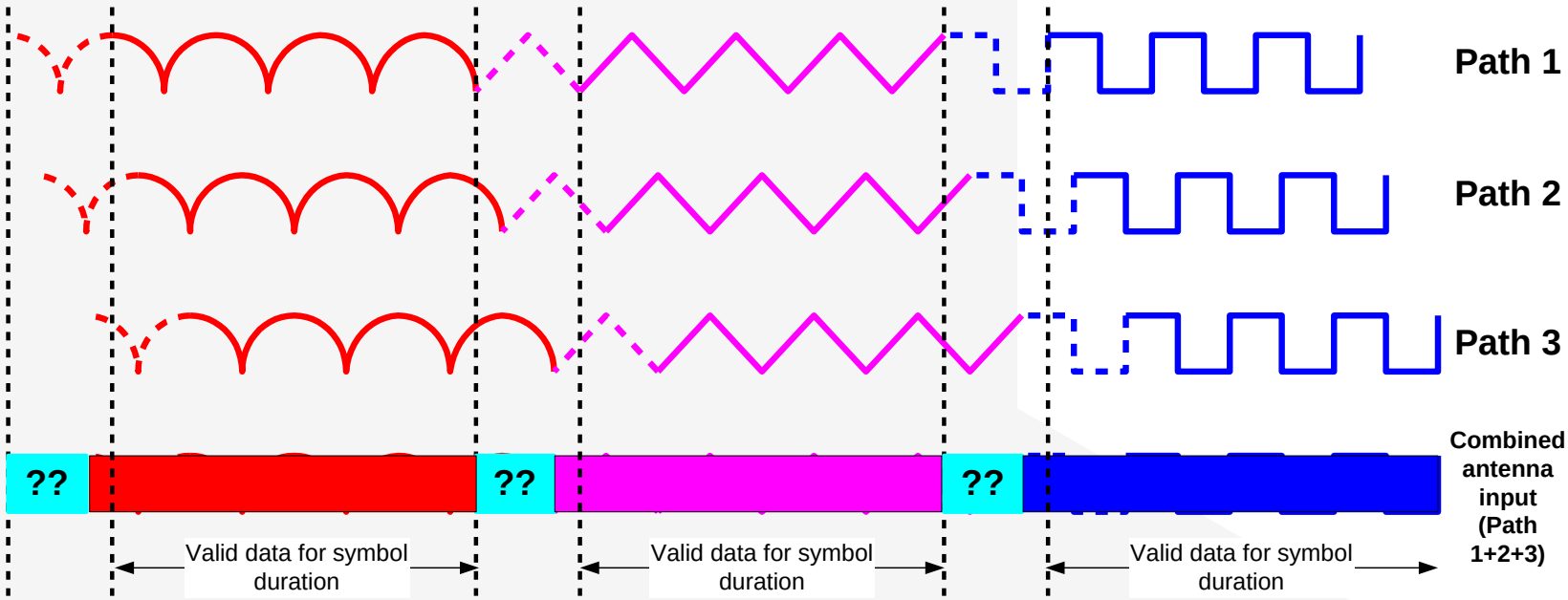
Data set number X+2 placed on carriers number 1 to n (2, 4 or 6 bits per carrier dependent on mode)



Symbol duration excluding symbol guard interval @ 8MHz
2K mode: 224us (0,000224 s)
4K mode: 448us (0,000448 s)
8K mode: 896us (0,000896 s)

Reception of signal with guard interval





But in analog FM, we can't use a guard interval. Now what?

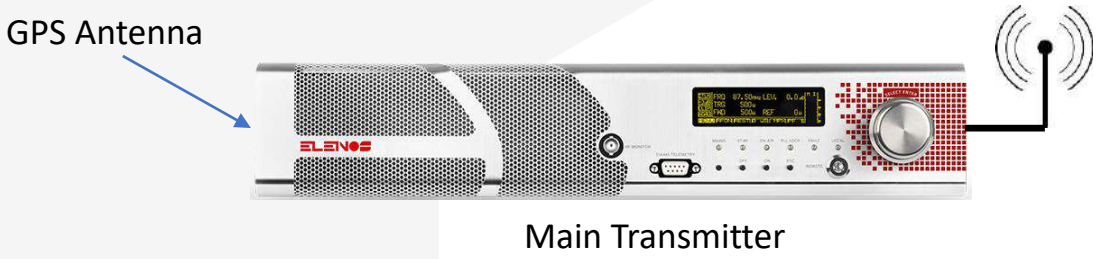
- When the main and booster signal are roughly the same level (the interference zone):
  - If the modulation index is different, terrible distortion is created which varies with the level of modulation.
  - If the RF frequencies are different, depending on the type receiver, noise and/or distortion are created.
  - If the pilots are not synchronized, additional noise is generated.
  - If the audio phase is not identical, distortion is created.
  - For best performance, the modulation index should be within 0.1dB, and audio phase within 1µs in the interference zone.
  - If everything is perfectly synchronized, multipath distortion will be heard, but this can be minimized with careful RF propagation planning.
- Monophonic FM exhibits much less multipath than Stereo.

RF coverage planning strategy

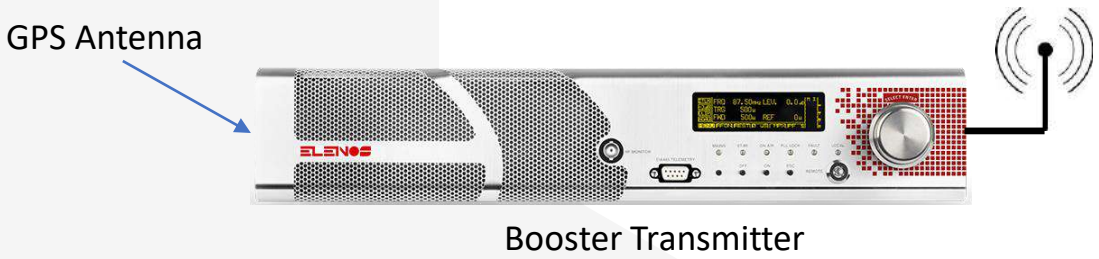
- The key is to minimize the size of the interference zone, and to place it where there are few listeners.
- This can be done with careful placement of transmitters, analysis of power levels and antenna types and patterns.
- Where possible, it's ideal to use terrain to separate the coverage areas, and to place the interference zone at highest points.
- Typically, RF consulting engineers are employed.
- Each µsec equals about 300 metres.

Assuring the RF frequency and pilot frequency and phase are identical

- The Elenos ETG digital exciter is available with an internal GPS receiver.
- This provides the 10MHz and 1pps references to perfectly synchronize:
  - RF carrier frequency
  - Pilot frequency and phase
  - Any internally generated SCA or RDS signals.



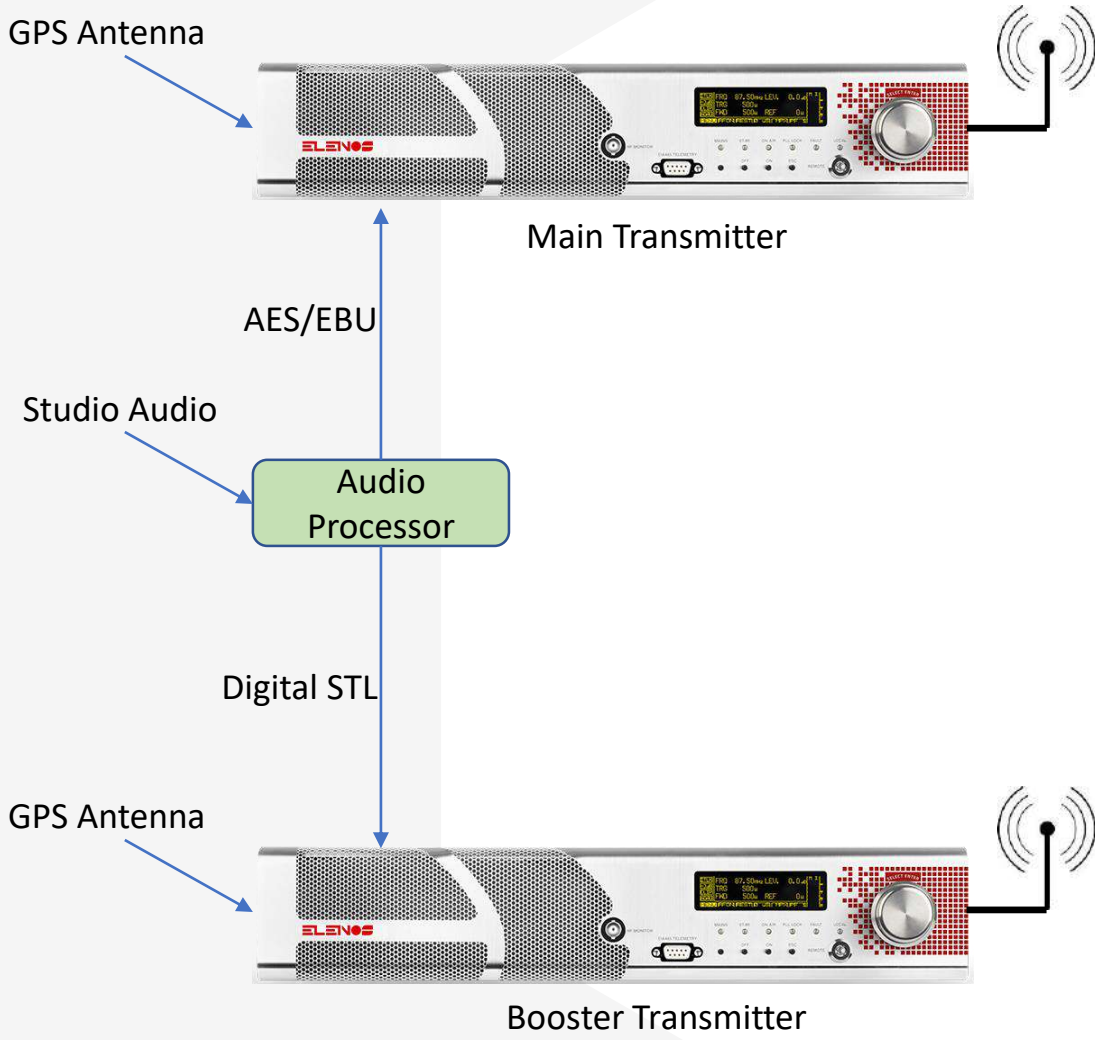
Main Transmitter



Booster Transmitter

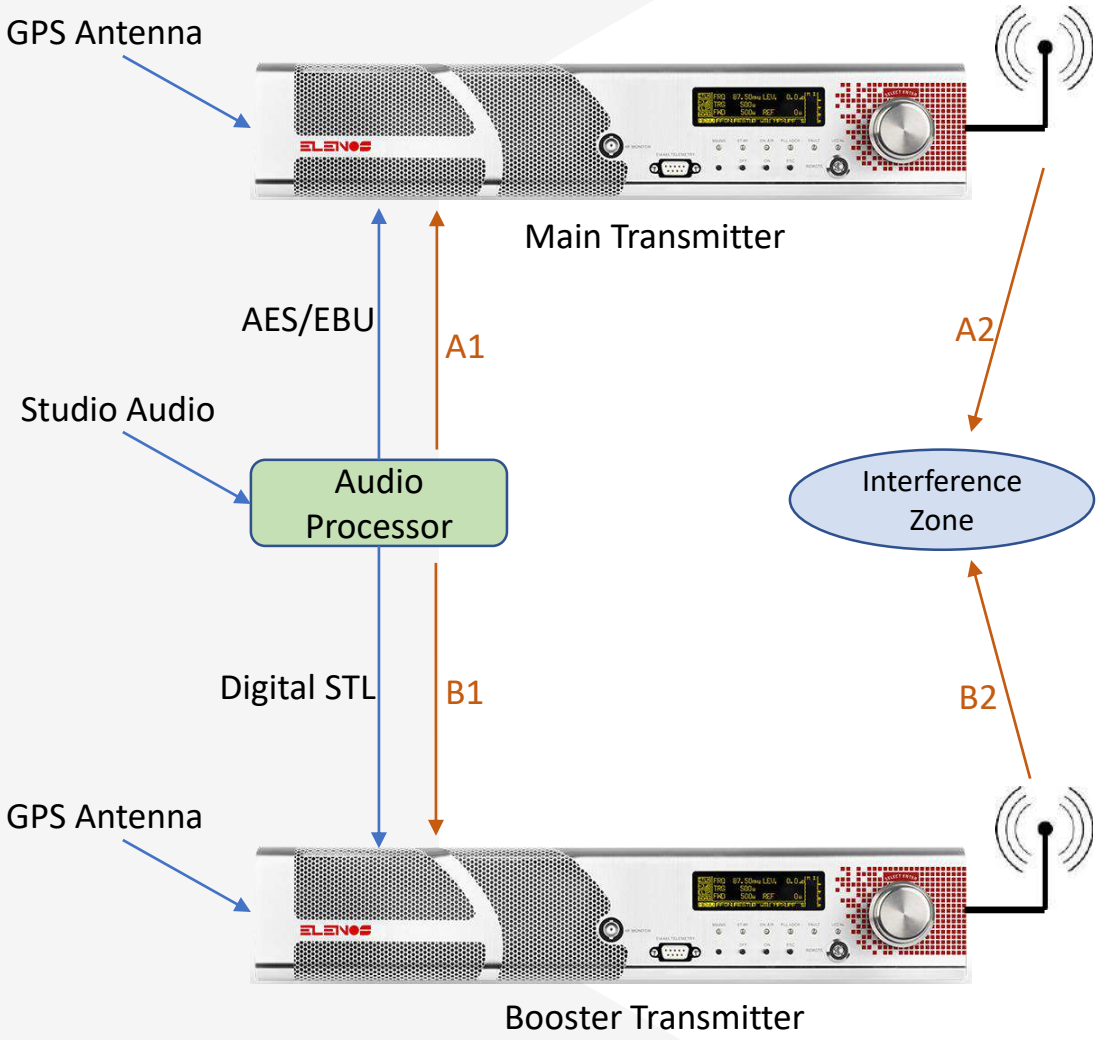
Assuring the modulation index is identical

- A totally digital signal distribution system is used.
- The same audio processing chain is used for both main and booster.
- The digital modulation gain is set in both exciters to the exact same figure.
- A good option to keep all the levels perfect is µMPX which encapsulates the entire composite baseband in a 320kbps data stream.



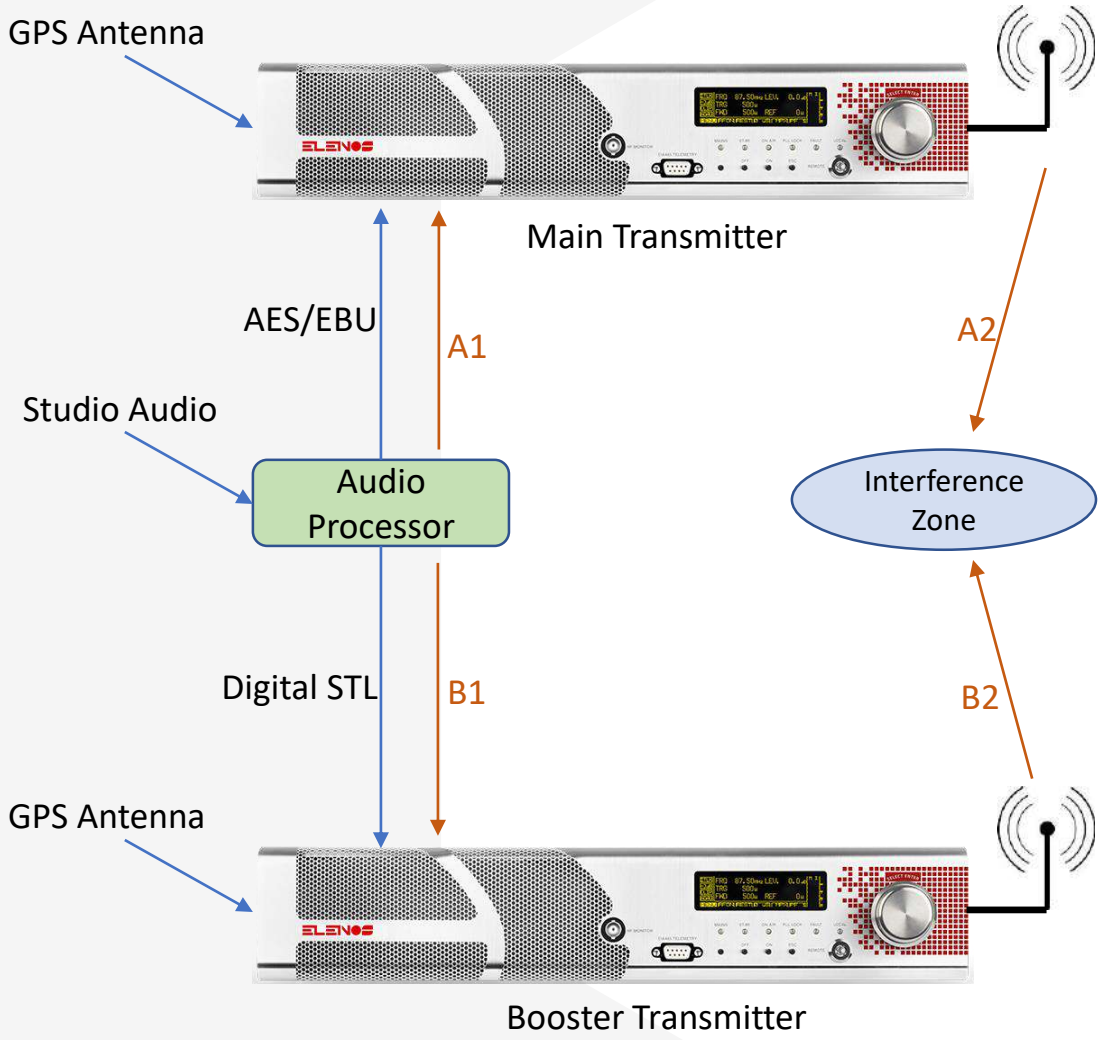
Getting the timing right

- Add the propagation time A1 to A2
- Add the propagation time B1 to B2
- Adjust the internal microdelay in the faster path to synchronize the timing.
- This works perfectly as long as the propagation time from the audio processor to each transmitter is stable. Satellite and Internet paths are *not* stable.



What do I do if the STL propagation time *isn't* stable?

- STL systems exist that can time stamp the digital audio based on GPS reference – and then resynchronize on the other end.



What happens if I use HD Radio?

- The analog FM signal and the two sets of digital sidebands can be considered separate.
- In HD Radio hybrid mode, the same issues exist for the analog FM signal.
- The digital HD carriers can be configured in with guard intervals in the same way as with Digital TV.
- Tests have proven that HD Radio SFNs are practical and offer excellent performance.

Summary

- SFN systems can work well, and are in use worldwide, but they require proper design and adjustment for optimal performance.
- Digital TV and Digital Radio (FM) work by employing a guard interval. When properly designed, the multiple signals compliment each other.
- Analog FM requires precise synchronization of modulation, frequency and timing, and even when perfect, multipath will be heard in the interference zone, expectation management is required!
- Because careful determination of the transmitter locations, antenna patterns and power levels is required, an RF consulting engineer is often utilized.
- Elenos ETG Digital Transmitters have the option of built in GPS for frequency and phase synchronization, and a micro-adjust time delay to allow perfect time synchronization.

Your Questions?

We'll try to answer them all here, but if we can't we'll email you.

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Thank You

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